

## Environmental Mental Models of College Students

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### ABSTRACT

Primary and secondary students in the United States are provided environmental education in their curricula due in part to national legislation, but higher education, for many U.S. citizens, is the last opportunity to educate young adults about the environment and humans' role in it in a formalized setting. Pre-college education and other life experiences or ways of learning can shape a student's mental model of the environment. While some previous research has focused on understanding environmental mental models of primary and secondary students, only one study to date has evaluated models of college students. Further, no study has evaluated potential shifts in mental models because of taking a course or what specific factors shape these models prior to college. The objectives of this study were to assess environmental models of college students and determine whether a course on "Environmental Conservation" reinforces or influences students' mental models by the end of the course. We compared environmental metal models at the start and end of our course using the Environments Task tool. Students were asked to provide pictorial and written descriptions of their mental models at both time periods. Additionally, photographs were used to explore student beliefs on environmental representations and questions were used to assess sources of prior environmental knowledge of students at the start of the semester. Results show that pictorial and written mental models differed from one another at the beginning as well as the end of the semester. More students identified humans as a part of the environment in their pictures by the end of the semester compared to the beginning, but no such shifts were noted in the written description. Students identified secondary school courses, life experiences such as growing up on a farm or ranch or hunting and fishing, and their family members as their primary sources of environmental information prior to taking the course. In total, these results indicate that mental models remain underdeveloped after this specific 16-week course and that these models may be more fixed by earlier educational experiences than previously believed. Recommendations for future environmental education are also provided.

### KEYWORDS

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### Introduction

Environmental knowledge has advanced in the United States through formal education since the passage of the National Environmental Education Act (NEEA). An estimated 30 million primary and secondary students (roughly 10% of the total number of primary and secondary students) and more than 1.2 million teachers (roughly 33% of all teachers) participate in environmental instruction in the United States on an annual basis (Coyle, 2005). Individual states within the United States are provided the freedom to define environmental curricula, but the

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overall goal of environmental education as defined by NEEA is to “improve understanding of the natural and built environment, and the relationships between humans and their environment, including the global aspects of environmental problems” (NEEA 1990). In spite of this legislation, the United States continues to face some of the most daunting and complex environmental challenges, including increased rates of extinction, climate change, and depletion of resources much more quickly than their renewal rates, to name a few. Most of these challenges have been linked to human behaviors, decisions, and activities.

Human behaviors and decisions are related to values, beliefs, prior knowledge, and views on how the world works (i.e., how objects and ideas are related and predictions of what may happen if certain decisions are made; Kollmuss & Agyeman, 2002). An individual’s internal representation of their working knowledge is referred to by cognitive psychologists and educators as a “mental model” (Johnson-Laird, 1983; Greca & Moreira, 2000). Mental models provide insights as to how individuals accept and reject knowledge to form a view of the world and how they act in accordance to various situations (Johnson-Laird, 1983). In contrast to values or beliefs which are formed early in life and are somewhat fixed, mental models are situational and could potentially be altered as a result of new knowledge or experience. Consequently, mental models may predict behaviors more accurately than values or beliefs (Jones et al., 2011). Thus, mental models may provide insight as to how students will behave toward the environment in the future (e.g., conservation practices, consumption decisions, political voting, etc.).

Previous studies have evaluated students’ mental models of the environment using drawings and written descriptions to gage conceptualization of the environment and the role of humans within it (Payne, 1998; Shepardson et al., 2007; Judson, 2011; Kalvaitis & Monhardt, 2011; Liu and Lin, 2015). Most of the research, to our knowledge, has focused largely on primary and secondary school students thus far. In total, these studies demonstrate that students’ concepts of the environment and the role of humans within it are related to education level and geography (i.e., urban versus rural settings). However, students’ mental models often lacked connections or relationships between aspects of their working knowledge, were not fully developed, or lacked sophistication across the entire sample of students, regardless of their demographics.

To our knowledge, only one study to date has evaluated undergraduate students’ mental models of the environment (Liu & Lin, 2015). A study of Taiwanese university students’ pictorial and written descriptions of the environment by Liu & Lin (2015) demonstrated similar undeveloped mental models as younger students studied by others in the United States (e.g., Payne, 1998; Shepardson et al., 2007; Judson, 2011; Kalvaitis & Monhardt, 2011). However, Taiwanese university students whose mental models were more complex and included humans as a part of the environment were more emotionally connected to the environment and participated in more activities that demonstrated their commitment to the environment.

We know of no study has evaluated the mental models of undergraduate students in the United States to date. Thus, the objectives of this study were to assess environmental models of college students and determine whether a course on “Environmental Conservation” reinforces or influences students’ mental models by the end of the course. We anticipated that undergraduate students at

our university should hold more developed mental models of the environment compared to younger students in previous studies (e.g., Payne, 1998; Shepardson et al., 2007; Judson, 2011; Kalvaitis & Monhardt, 2011) or foreign students (Lin & Liu, 2015) because many primary and secondary students in the United States have engaged with environmental curricula throughout their education. Universities may provide the last formal educational opportunity for environmental educators to potentially influence student views and behaviors toward the environment in a formalized setting. Universities or colleges may offer general courses taught to a broad audience of majors which focus on concepts related to the environment and environmental ethics, either at the state, national, or international scale or integrate environmental conservation concepts such as “sustainability” to their curricula (Cortese, 2003).

In this study, we examine the environmental mental models of college students at the beginning of the semester, identify the various educational experiences (e.g., classrooms, life experiences, readings) that have previously influenced those mental models, and evaluate whether our 16-week course entitled “Environmental Conservation” influenced any shifts in those models by the end of the semester. Our overall hypothesis was that students would have a more developed mental model of the environment that included humans as a result of our course.

## Methods

This study was conducted during the fall 2014 semester. The population of interest included students enrolled in NRM 110 – Environmental Conservation (title of course changed to “Introduction to Natural Resource Management” effective fall 2015). The course serves two audiences: 1) those who are first-year students enrolled in any of the Department of Natural Resource Management (NRM) majors at South Dakota State University (i.e., ecology and environmental management; natural resource law enforcement; rangeland ecology and management; wildlife and fisheries sciences); and 2) the general university population of students who enrolled in the course to fulfill a university graduation requirement to learn social and environmental responsibility. Most of the course was structured around case studies based on real-life complex environmental issues that involved human values and decisions or active learning exercises where students evaluated their personal impact on the environment (e.g., calculating personal carbon or ecological footprints). Textbook readings were used to provide background knowledge on the theme of the case study or active learning exercise, and lectures were used minimally. A total of 136 students completed the course; 34% were NRM majors. The course was co-instructed by the three authors (two instructors and a teaching assistant) who had a combined 11 years of experience teaching this course.

To assess students’ mental models of the environment at the start of the semester, we created an in-class activity based on the Environments Task tool developed by Osborne & Freyberg (1985) and used by Shepardson et al. (2007) to assess the same mental models for students in grades 4 through 12 in eight states (see Appendix for the see Supplemental Material). Specifically, we requested students to provide labeled hand-drawn pictures that described their definition of the “environment” as well as a more-thorough written description of the picture. We categorized the pictorial and written descriptions separately based on the same models and specific categories identified by Shepardson et al. (2007; Table



1). Briefly, Model 1 describes the environment as a natural place or a place where animals and plants live; this model is further subdivided into five more specific categories (Table 1). Model 2 describes the environment as supporting life; this model is further subdivided into five specific categories. Model 3 describes the environment as a place which has been impacted or modified by humans; this model is further divided into two specific categories. Model 4, the model emphasized by the instructors of this course throughout the semester, describes the environment as a place where animals, plants, and humans live. This model is not divided into further specific categories.

**Table 1.** Mental models of the environment identified by Shepardson et al. (2007) that were used to categorize college students' mental models in this study.

Mental model	Description	Specific category	Description
1	A place where animals/plants live, a natural place	a	Place where animals/plants live
		b	Natural place, nature
		c	Living and non-living
		d	Cycling of matter
		e	Energy transfer
2	Supports life	a	Supports animal life
		b	Supports human and animal/plant life
		c	Supports human life
		d	Supports animal/plant life
		e	Supports human and animal life
3	A place impacted or modified by humans	a	Place where only people live (Built environment)
4	A place where animals, plants, and humans live	b	Polluted environment
		a	Place where animals, plants, and people live

Additionally, we also presented students with seven photographs similar to the ones provided in the Shepardson et al. (2007) study and asked students whether they believed the photograph represented an "environment" based on their personal definition (see Appendix for the Supplemental Material). In short, these seven photographs represent different natural and human-managed environments, including: an urban residential development (Photograph 1); an undisturbed deciduous forest (Photograph 2); an aerial view of an agricultural landscape (Photograph 3); a waterbody where humans are recreating but no other non-human life is observed (Photograph 4); a dessert (Photograph 5); bears in a water environment (Photograph 6); and a commercial development (Photograph 7). Finally, we asked students what sources of prior knowledge informed their current definition of the environment; common responses were tallied.

We were also interested in whether students' mental models of the environment shifted as a result of completing the NRM 110 course, with a particular focus on recognizing that humans are a part of the environment rather than separate from other living and non-living components. To assess mental models at the end of the semester, we asked students on the final exam activity to provide a pictorial and written description of the environment as we did at the beginning of the semester. Again, the pictorial and written descriptions were categorized according to the models identified by Shepardson et al. (2007; Table 1).

Chi-squared tests of homogeneity were used in four different analyses designed to test for the following:

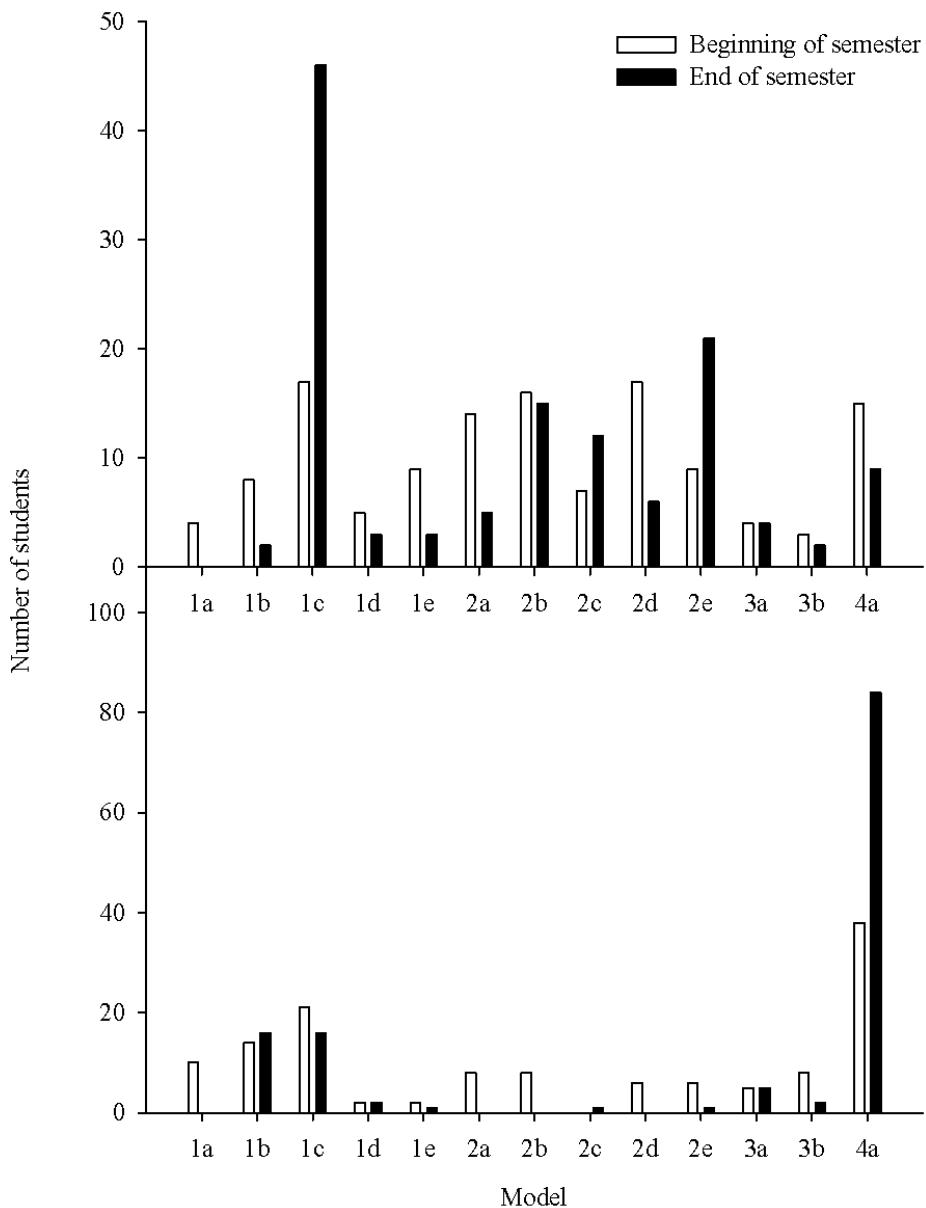
- 1) Determine whether the frequency of the pictorial classifications was similar to the frequency of the written classifications at the start of the semester;
- 2) Determine whether the frequency of the pictorial classifications was similar to the frequency of the written classifications at the end of the semester;
- 3) Determine whether the frequency of the pictorial classifications differed between the beginning and the end of the semester; and
- 4) Determine whether the frequency of the written classifications differed between the beginning and the end of the semester.

Statistical significance was determined at  $\alpha = 0.05$ . If significance was detected, then pairwise comparisons were made between the frequencies of the four models using paired t-tests. We used a Bonferroni correction to account for multiple comparisons, so significance was determined at  $\alpha = 0.05/4 = 0.01$ .

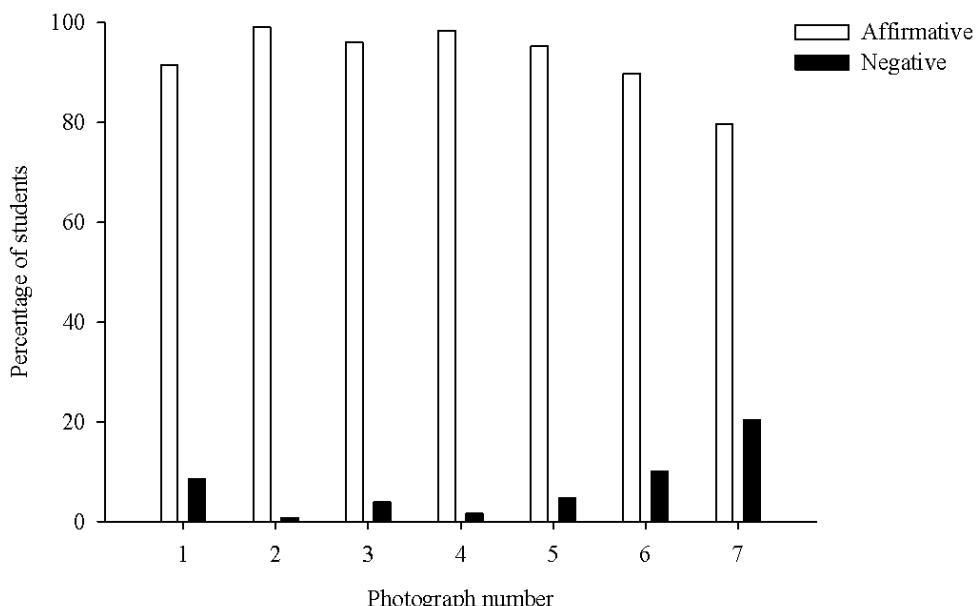
## Results

The frequency of students' mental models at the start of the semester differed significantly between what they presented in pictures versus their written descriptions ( $\chi^2 = 26.63$ ,  $df = 3$ ,  $p < 0.001$ ). Specifically, students more frequently drew the environment as a place where animals, plants, and humans live (Model 4) than they described in written form ( $p < 0.01$ ). However, student more frequently described the environment as supporting life (Model 2) in written form more frequently than they illustrated this model ( $p < 0.01$ ; Figure 1). A nearly equal proportion of students illustrated or provided written descriptions of the environment as a place where animals and plants live or a natural place (Model 1) or a place impacted or modified by humans (Model 3) during this time period.

More than 89% of students classified the first six photographs (i.e., an urban residential development; an undisturbed deciduous forest; an aerial view of an agricultural landscape; a waterbody where humans are recreating but no other non-human life is observed; a dessert; and bears in a water environment; see Appendix for the Supplemental Material) as a representation of an environment (Figure 2). Approximately 20% of the students stated that the commercial development (Photograph 7) was not a representation of the environment. Of those, 46% of their drawings described the environment as a place where animals and plants live or a natural place (Model 1) and 54% of their written descriptions described the environment as a place that supports life (Model 2). Approximately 10% of all students stated that the photo of the bears in the water (Photograph 6) was not a representation of the environment. Of those, more than half of their drawings described the environmental as a place where animals and plants live or a natural place (Model 1) and 61% of their written descriptions describe the environment as a place that supports life (Model 2; Table 2).



**Figure 1.** Comparisons of the frequencies of model categorizations of student pictorial descriptions of the environment (top panel) and their written definitions of the term (bottom panel) at the beginning and end of the fall 2014 semester. Explanations of model categories are provided in Table 1.

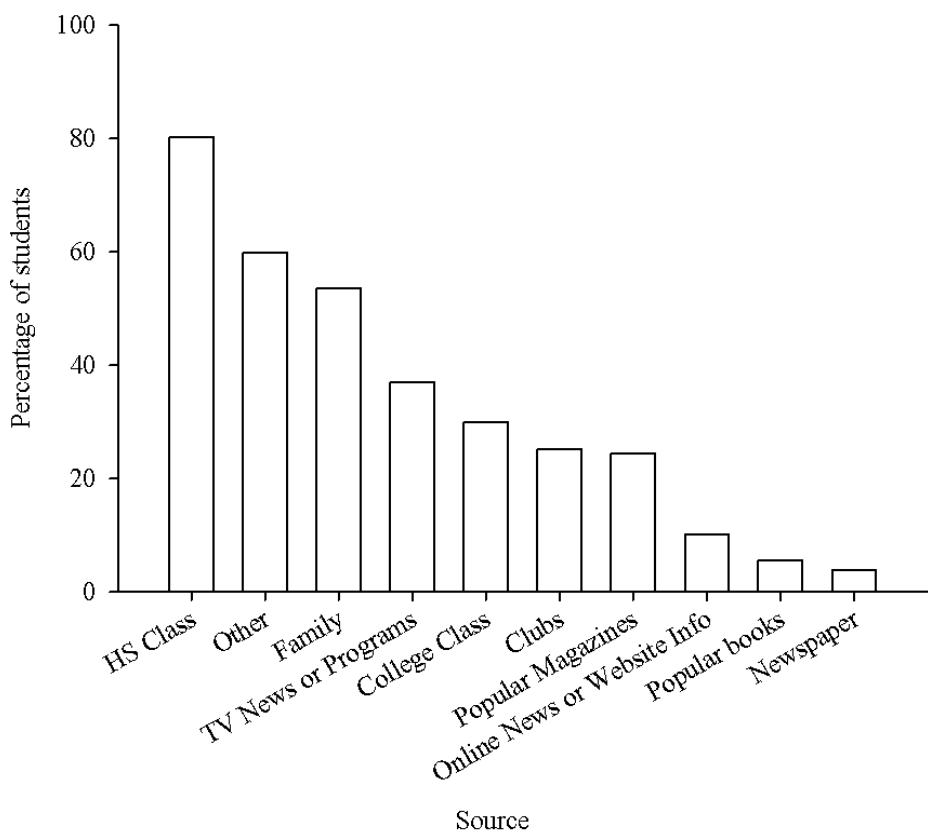


**Figure 2.** Frequency of students stating whether each of the seven photographs they were presented at the beginning of the semester (see Appendix for the Supplemental Material) represented an environment according to their personal definitions.

**Table 2.** Number of the pictorial and written description classifications among those students who did not believe that Photographs 6 and 7 (see Appendix for the Supplemental Material) represented an environment. Explanations of model categories are provided in Table 1.

Model category	Photograph 6		Photograph 7	
	Pictorial	Written	Pictorial	Written
1a	0	0	0	1
1b	5	1	3	0
1c	2	2	8	6
1d	0	0	0	0
1e	0	0	1	4
2a	1	2	3	5
2b	0	0	1	1
2c	0	1	0	1
2d	1	3	1	4
2e	1	2	3	3
3a	0	0	0	0
3b	1	0	0	0
4a	2	2	6	1
<b>TOTALS</b>	<b>13</b>	<b>13</b>	<b>26</b>	<b>26</b>

Most students reported receiving prior knowledge about what defines an environment from a high school course (80%; Figure 3). Family was the second most common response (53%). Newspapers and books were the least reported source of information (4 and 6%, respectively). The “other” responses (25%) provided most frequently included sources such as “spending time in the outdoors”, “living on a farm or ranch”, or “through hunting and fishing.”



**Figure 3.** Frequency of the sources of prior information that students identified in informing their definition of the environment prior to enrolling in the NRM 110 courses in fall 2014.

Pictorial and written depictions of the environment also differed from one another at the end of the semester ( $\chi^2 = 117.88$ ,  $df = 3$ ,  $p < 0.001$ ). Students wrote the environment as a place where animals and plants live or a natural place (Model 1) and a place that supports life (Model 2) more frequently than drawn ( $p = 0.01$  and  $p < 0.01$ , respectively), but students more frequently illustrated the environment as a place where animals, plants, and humans lived was more frequently than written ( $p < 0.01$ ; Figure 1). Students wrote and illustrated that the environment is a place impacted or modified by humans in equal frequency (Figure 1).

Written descriptions were similar at the beginning and end of the semester ( $\chi^2 = 2.96$ ,  $df = 3$ ,  $p = 0.40$ ); however, the frequency of picture categories at the beginning versus the end of the course did differ significantly ( $\chi^2 = 44.01$ ,  $df = 3$ ,  $p < 0.001$ ). Students drew the environment as a place that supports life (Model 2) less frequently at the end of the semester compared to the beginning of the semester ( $p < 0.01$ ) but drew the environment as a place where animals, plants, and humans live (Model 4) more frequently at the end of the semester ( $p < 0.01$ ; Figure 1). Nearly equal proportions of students drew the environment as a place where animals or plants live or a natural place (Model 1) or as a place impacted or modified by humans (Model 3) between both time periods (Figure 1).

## Discussion

Results from our study indicate two potentially interesting findings in regards to mental models overall: 1) mental models may be inconsistent or underdeveloped; and 2) mental models may be more fixed by prior education and life experiences than previously believed. The lack of consistency in written and pictorial descriptions at both the beginning and end of the semester provide evidence of inconsistent mental models. If mental models were fully developed, then we may expect that the frequency of model types would be consistent in both written and oral descriptions at both points in time or at least by the end of the semester. Such differences may indicate that while students recognize that humans live in the environment, a full understanding of the relationship between humans and the environment is still lacking.

Despite national legislation that focuses on improving students' understanding of the role of humans in the environment at the primary and secondary education level (NEEA 1990), most students began this course with undeveloped written or pictorial mental model of the environment that did not include humans. By the end of this course, students were beginning to recognize that humans are a part of the environment, as least as indicated by the increase in pictorial representations. Perhaps one college course was not enough to help students reconcile their mental models of the environment, particularly if previous life and educational experiences had reinforced their mental models over time. Alternatively, perhaps the course structure could be improved to help students reconcile these models. For example, the case studies and active learning exercises were selected to emphasize the role that humans play in the environment, but the instructors could build in post-assignment debriefings that required students to further discuss and reflect on what they learned about the impact that humans had on that particular environmental issue. This additional reflection may help students create meaning between the learning activity and the overall theme of the course as well as allow the instructors to monitor students' progress at various points throughout the semester (Costa & Kallick, 2008). Judson (2011) also noted that teaching and learning activities related to the environment need to explicitly examine and challenge students' environmental mental models in order for true shifts to occur.

Previous research shows that mental models are context specific and could shift based on time and situation (Greca & Moreira, 2000; Shepardson et al., 2007; Jones et al., 2011), but we found little to no shifts of students in our class overall. Mental models are certainly rooted in culture, education, and personal experience (see Jones et al., 2011 for a review), and our study supports this thought for college students as indicated in students' responses in the "other" category. Additionally, students often noted a family member such as a father, uncle, or grandfather who spent time with them outdoors. Much has been written about the lack of exposure to nature in young children and how this may affect environmental stewardship in the future (see Leopold, 1966; and Louv 2008, 2012). Judson (2011) found that students' mental models of desert environments were not affected by field trips alone but may shift and become more complex if parents are involved in the learning process. Overall, mental models may be fixed earlier in life and influenced by role models and experiences and further research should explore these relationships.



Another cultural influence on students' mental models of the environment but not directly measured in this study may be a rural or urban upbringing. We did not ask students the population size of their hometowns. A large portion of students at the university are from the state of South Dakota, and more than 50% of the state is considered "rural" based on population size (U.S. Census, 2010). Further, the prevalence of farming, ranching, hunting, fishing, and club activities such as Future Farmers of America and 4-H in student responses are indicative of a more rural upbringing. Shepardson et al. (2007) noted urban, suburban, and rural students wrote and drew the environmental as a place where plants and animals live or a natural place at equal frequencies, but urban students drew or described the environment as a place impacted or modified by humans more frequently than suburban or rural students. Those from rural backgrounds may be more likely to have a utilitarian view toward the environment, believing that natural resources exist for the benefit of humans by providing goods such as grain, meat, and fur (Teel & Manfredo 2010). Such beliefs may explain the prevalence of written and pictorial descriptions of the environment as a place where animals and plants live or a natural place (Model 1) or a place that supports life (Model 2) at the beginning and the end of the course despite direct education of the role of humans in the environment.

In contrast, students from urban backgrounds may be more distanced from the natural world (Manfredo et al., 2003; Heberlein & Ericsson, 2005). A 2004 survey of western states showed that only 6% of South Dakota residents would be classified as "distanced," based on their views (Manfredo 2008; Teel & Manfredo, 2010). However, the demographics of students at the university have changed in the past decade either as larger towns in South Dakota have grown or students are recruited from more urbanized states within the region and other countries. Approximately 47% of South Dakota State University students now come from other states or countries as compared to 33% just 10 years ago, (Zhang, 2015). Future studies might examine longitudinal trends in students' mental models of the environment to evaluate the relative influence of rural and urban upbringings on these models.

In total, the results of this study may lead to further discussion and research on whether a college educational experience can influence one's pre-existing mental models about the environment. Holding simple or underdeveloped mental models may influence one's openness to new information (Johnson-Laird, 1983; Jones et al., 2011) and future environmental conservation behaviors (Lin & Liu, 2015). In fact, Lin & Liu (2015) found that Taiwanese college students who hold more complex mental models of the environment are more likely hold more positive emotions toward the environment or engage in behaviors that promote conservation in the future, such as voting for pro-environmental candidates or purchasing goods that are energy efficient. While we as co-instructors of the course emphasized the role of humans in the environment continuously throughout the 16-week semester through various learning activities (e.g., lectures, in-class case studies, personal analyses and reflections), many students still seemed to hold mental models that did not include humans as a part of the environment. Without recognizing the role of humans in the environment by the end of this course, it may be less likely that conservation or stewardship behaviors of our students will change in the future. Further, these students may be less likely to seek out additional knowledge about the environment and what they can personally do to conserve or protect it in the future. Future studies should

examine other methods to challenge students' mental models of the environment at all ages and whether shifts in those models eventually result in conservation of stewardship behaviors.

### Disclosure statement

No potential conflict of interest was reported by the authors.

### Notes on contributors

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## Appendix: Supplemental Material (Slides)

<p>So, what is the “environment”?</p>  <p>Let's see what you know!</p>	<p><b>Part I: Definition</b></p> <ul style="list-style-type: none"><li>Part A: Exercise your art muscle! Draw what you think the environment is (what it looks like). Label the parts of your drawing.</li></ul> 
<p><b>Part I: Definition</b></p> <ul style="list-style-type: none"><li>Part B: Below your drawing, write several sentences that explains why your drawing is an environment. That is, what makes it an environment?</li></ul>	<p><b>Part II: What do you think?</b></p> <ul style="list-style-type: none"><li>Review the next series of pictures. Number your response to the following according to the number of the picture. Do you think the photograph depicts the environment? Justify your response to the question.</li></ul>
<p>Picture 1</p> 	<p>Picture 2</p> 
<p>Picture 3</p> 	<p>Picture 4</p> 
<p>Picture 5</p> 	<p>Picture 6</p> 
<p>Picture 7</p> 	<p><b>Part III: Previous Learning</b></p> <ul style="list-style-type: none"><li>Where did you learn about the environment? Provide a list.<ul style="list-style-type: none"><li>High school classes</li><li>College classes</li><li>Family</li><li>News (TV, online, newspaper) -list titles</li><li>Popular magazines -list titles</li><li>Popular books -list titles</li><li>Extracurricular clubs (e.g., 4-H, FFA)</li><li>Anything else you can think of.</li></ul></li></ul>